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## The Composition of Milk Products

### INTRODUCTION

The principal feature of the manufacture of nearly all commercial milk products is essentially the separation of one or more constituents from the milk. Either the substance is isolated or the remaining mixture, or both, may be products of value. This separation is, in most instances, not sharp; hence, practically all milk products contain all the constituents of milk, but with the proportions of one or more considerably altered. For example, in the concentration of whole milk the alteration is in the ratio of water to the other components. By means of the cream separator, on the other hand, are obtained two products of value—the cream, containing practically all of the milkfat; and the skim milk, containing the bulk of the solids other than fat. Both cream and skim milk may be concentrated by removal of water, but, even after these operations, the relative proportions of protein, lactose, and salts are practically the same as in the original milk. Cream from the separator may be churned to produce butter, which differs analytically from cream in that solids-not-fat have been removed in addition to water. The butter-milk from sweet cream butter is practically the same in composition as skim milk. Butter may be melted and butteroil separated, which represents what may be considered the final step in the concentration of milkfat.

The manufacture of cheese is essentially the preparation of a mixture of casein and fat. In the cheese-making process, the proportions of all the principal milk constituents are changed relative to one another. In contrast to cream, butter, casein, and lactose—the latter two being essentially concentrated single constituents—such products as ice cream and sweetened condensed milk require the addition of considerable quantities of substances foreign to milk. In a few products, such as cheese and cultured buttermilk,

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certain of the milk constituents are chemically changed by bacterial action.

The changes in composition which occur in dairy manufacturing processes have been pointed out in order that it may be clear why each milk product resembles milk from the analytical standpoint in some respects but not in others. Any single product may vary considerably, its composition depending on the composition of the raw milk used in its manufacture and on the method of processing as determined by the aims of the producer or the desires of his customers. In the manufacture of most dairy products, an effort is made to have the composition barely exceed the minimal legal standard.

In the following discussions, typical compositions are given wherever practicable. Information is included on state and federal standards in force at the time of writing. Tables of amounts of vitamins in milk and milk products will be found in Chapter 7.

### EVAPORATED MILK

This product is made by evaporating water from whole milk under a vacuum. The homogenized, concentrated product, usually containing added vitamin D, is transferred to small cans and sterilized under pressure at 116°C. for 15 min., or at equally effective combinations of temperature and time, to kill microorganisms, inactivate enzymes, and develop the desired viscosity.

Determined efforts are being made to manufacture an improved product by sterilizing the whole milk in a high temperature-short time operation and then completing all subsequent steps under aseptic conditions.

Federal standards of identity require that evaporated milk contain not less than 7.9% milkfat and not less than 25.9% total milk solids. Several states permit a minimum of 7.8% fat; one state, 7.7%. About one-third of the states permit a minimum of 25.5% total milk solids. One pound of evaporated milk is considered equivalent to 2.1 lb. of fluid milk. Hence, milk containing 3.77% fat and 12.34% total milk solids, when concentrated in the ratio of 2.1 to 1.0, meets the federal standard for evaporated milk. A typical composition is: 73.8% water, 7.9% fat, 7.0% protein, 9.7% lactose, and 1.6% ash.<sup>6</sup>

### PLAIN CONDENSED MILK

This product is made by concentrating whole milk under vacuum to concentrations ranging from 2.5:1 to 4:1, the usual ratio being

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2.8:1. Considering the source of whole milk to be the same as that for the evaporated milk described above, the composition of plain condensed milk would be: 65.0% water, 10.5% fat, 9.4% protein, 13.0% lactose, and 2.1% ash. Plain condensed milk is shipped in bulk containers and is highly perishable.

A product of the above composition for retail distribution is made in such a way as to sterilize or nearly sterilize it. Because of its relatively good keeping quality and economies in packaging and distribution it is receiving increasing attention, particularly as a source of beverage milk.

### SWEETENED CONDENSED MILK

To make sweetened condensed milk, approximately 18 lb. of sugar is added to each 100 lb. of milk and the mixture is concentrated under vacuum. The product is canned without sterilizing, the sugar acting as a preservative. Federal standards of identity require that sweetened condensed milk contain not less than 8.5% milkfat and not less than 28.0% total milk solids. State standards are as low as 7.7% fat in one state, with the majority at 8.0 and 8.5%. One pound of sweetened condensed milk, as made in the United States, is considered equivalent to 2.2 lb. of fluid milk. A typical composition is: 26.5% water, 8.1% fat, 8.1% protein, 55.7% carbohydrate (11.4% lactose, 44.3% sucrose), and 1.6% ash.<sup>6</sup>

### DRY WHOLE MILK

Whole milk is dried either by a spray or drum process. Before drying, the milk is usually concentrated under vacuum in a ratio that may be greater than 3 to 1. The product usually is packaged in cans, the air being replaced by nitrogen or a mixture of nitrogen and carbon dioxide. There are no federal standards of identity for the composition of this product. Only about half the states have standards, these being the same for the most part at 26.0% milkfat (minimum) and/or 5.0% moisture (maximum). One state requires a minimum of 27.0% milkfat. One pound of dry whole milk is considered equivalent to 8 lb. of fluid milk. A typical composition is: 2.0% moisture 27.5% fat, 26.4% protein, 38.2% lactose, and 5.9% ash.

### MALTED MILK

Malted milk is made by concentrating a mixture of milk and an extract from a mash of ground barley malt and wheat flour, to obtain a solid which is ground to powder. It contains not less

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than 7.5% milkfat and not more than 3.5% moisture. One pound is considered equivalent to 2.65 lb. of fluid milk on the basis of fat content and to 4.4 lb. on the basis of solids-not-fat content. This difference in equivalents results from using milk containing approximately 2.0% fat in making malted milk. A representative composition is: 2.6% moisture, 8.3% fat, 14.7% protein, 70.8% carbohydrate, (20.0% lactose, 50.5% maltose and dextrin, and 0.3% fiber), and 3.6% ash.

### CREAM

Cream consists of the fat of milk together with a decreased proportion of the other solids and the water of milk. The ratio of water to solids-not-fat in cream is the same as that in the milk from which the cream was produced. Cream may contain from 18 to 80% fat, the percentage depending upon the speed of the separator, the temperature of the milk, the rate of milk in flow, the setting of the cream screw, and the number of times the product is run through the separator. It is the usual practice in the United States to offer at retail three types of sweet cream, containing approximately 18, 30, and 36% fat, respectively. A product made for manufacturing purposes and containing usually about 80% fat, is known as plastic cream. Federal standards of identity<sup>5</sup> require that light, coffee or table cream contain not less than 18% milkfat, but less than 30%; light whipping cream, not less than 30% milkfat but less than 36%; heavy whipping cream, not less than 36% milkfat. State standards differ from these in some instances. Table 16 gives calculated compositions of several types of cream, the composition of the milk on which the calculations are based, and the milk equivalents on the fat basis.

TABLE 16  
THE COMPOSITION (IN PER CENT) OF CREAM

	Water	Fat	Protein	Lactose	Ash	Milk Equiv- alent
Milk	87.0	3.9	3.5	4.9	0.7	1.0
"Half-and-half"	80.2	11.5	3.1	4.5	0.7	3.1
18% Cream	74.5	18.0	2.8	4.1	0.6	5.2
30% Cream	63.3	30.0	2.5	3.6	0.6	7.9
36% Cream	58.0	36.0	2.2	3.3	0.5	9.4
Plastic cream	18.2	80.0	0.7	1.0	0.1	21.0

A mixture of milk and cream, called "Half-and-Half," is widely used with cereals and in coffee. The composition is given in Table 16.

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There are two types of sour cream. Both contain not less than 18.0% milkfat and have an acidity of not less than 0.6%. But one type must contain not less than 7.0% milk-solids-not-fat while the minimum milk-solids-not-fat for the other type is 9.0%. The cream is pasteurized and homogenized, inoculated with sufficient quantity of desirable lactic acid culture to produce a smooth, uniform, coagulum; fermented, packaged, and cooled to 5°C. or lower.

A small quantity of dry cream is manufactured in the United States, usually by the spray process. Since in this product the ratio between the fat and solids-not-fat is the same as that of the cream before drying, the composition of dry creams differs with differences in the fat percentage of the creams from which they are made. The analyses in Table 17 are from the circular of a manufacturer and represent dry creams made from fluid products containing approximately 10, 15, and 20% fat, respectively.

TABLE 17  
THE COMPOSITION (IN PER CENT) OF DRY CREAM

Sample	Water	Fat	Protein	Lactose	Ash
1	0.80	50.40	19.19	25.45	4.16
2	0.66	65.15	13.42	17.86	2.91
3	0.56	71.15	11.12	14.74	2.43

### SKIMMILK

The percentage of all constituents of skimmilk, except, of course the fat, are proportionally greater than in the whole milk from which it is made. There is no federal standard for skimmilk. About half the states define skimmilk as milk from which a sufficient portion of milkfat has been removed to reduce its milkfat content to less than the minimum for whole milk. A minimum percentage of milk solids in the range of 8.25 to 9.3 is usually specified. A few states specify an X percentage of milkfat from skimmilk, ranging from 0.25 to 1.0%. A typical composition<sup>e</sup> is: 90.5% water, 0.1% fat, 3.6% protein, 5.1% lactose, and 0.7% ash. Many states define a product designated as nonfat, fat-free or defatted milk which is skimmilk containing an X percentage of milkfat, ranging from 0.10 to 0.50%. In some instances provision is made for the addition of skimmilk solids.

Several states have a standard for an additional skimmilk product containing about 2.0% milkfat and usually with about 1 to 2% skimmilk solids added.

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### PLAIN CONDENSED SKIMMILK

By far the largest proportion of concentrated skimmilk produced in the United States is marketed in bulk as plain condensed skimmilk. About half the states have minimal standards for condensed skimmilk. These standards vary from 18 to 28% milk solids. The products on the market vary in composition over the range indicated in Table 18.

TABLE 18  
THE COMPOSITION (IN PER CENT) OF CONDENSED SKIMMILK

	Nonfat Milk Solids	Fat	Protein	Lactose	Ash	Sucrose
Plain	27.0	0.3	10.0	14.7	2.3	...
Plain	34.0	0.4	12.7	18.4	2.9	...
Sweetened	30.0	0.3	11.2	16.3	2.5	42.0

A small quantity of concentrated skimmilk, containing not less than 20% of milk solids, is sterilized in cans and sold as evaporated skimmilk.

### SWEETENED CONDENSED SKIMMILK

A small quantity of sweetened condensed skimmilk is marketed in retail-size cans, but most of it is handled in bulk containers. A typical analysis of sweetened condensed skimmilk is given in Table 18.

### CONCENTRATED SOUR SKIMMILK

This is a product manufactured for animal feed. It usually is made from skimmilk which has been pasteurized and then soured by means of a pure culture of lactic bacteria before concentrating, but may be made from a mixture of skimmilk and whey pasteurized and soured separately before combining and concentrating. Table 19 gives the approximate composition of these products.<sup>3</sup>

TABLE 19  
THE COMPOSITION (IN PER CENT) OF CONCENTRATED SOUR SKIMMILK

	Water	Protein	Fat	Lactose	Ash	Acid as Lactic
From skimmilk	72.00	10.19	0.17	9.43	2.13	6.08
From skimmilk plus whey	69.69	8.26	0.20	13.46	2.54	5.85

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### NONFAT DRY MILK

This product was defined by an Act of Congress of March 2, 1944, as follows: "That for the purposes of the Federal Food, Drug and Cosmetic Act of June 26, 1938, nonfat dry milk solids or de-fatted milk solids is the product resulting from the removal of fat and water from milk, and contains the lactose, milk proteins, and milk minerals in the same relative proportions as in the fresh milk from which made. It contains not over five per cent by weight of moisture. Fat content is not over  $1\frac{1}{2}\%$  by weight unless otherwise specified. The term 'milk' when used herein, means sweet milk of cows." In 1956, the law was changed to name the product "nonfat dry milk." Several states have one or both of these specifications of composition.

Most "instant" nonfat dry milk is made from the conventionally spray dried product by exposing it to steam to cause the particles to agglomerate and part of the lactose to crystallize. The excess moisture is evaporated with mild heat and the product sieved. Instant nonfat dry milk is less hygroscopic and more readily soluble than the non-instantized powder.

One pound of nonfat dry milk is equivalent to approximately 11 lb. of fluid skim milk. A typical composition is: 3.0% moisture, 0.8% fat, 35.9% protein, 52.3% lactose, and 8.0% ash.

### BUTTER

The federal standard (the Act of March 4, 1923, 42 Stat. 1500), requires that butter contain not less than 80% milkfat. Nearly all states specify this minimum of fat and several specify that butter contain not more than 16% water. The following composition is typical: 16.5% moisture, 80.5% fat, 0.7% curd, and 2.3% salt.

### BUTTEROIL

Butteroil or anhydrous milkfat is a refined product made by centrifuging melted butter or by separating the milkfat from high-fat cream. The product contains only small amounts of moisture and gases held in solution. Their presence can be demonstrated only by the use of high vacuum. The composition is 99.5% milkfat, 0.2% moisture and 0.3% protein.<sup>6</sup>

### BUTTERMILK

Buttermilk is of two kinds—that obtained as a by-product in the churning of cream to produce butter and that prepared from skim-milk through the action of a culture of lactic acid organisms. The

latter is often called cultured buttermilk. Buttermilks are similar to skimmilk in composition, except that lactic acid—the total acidity calculated as lactic acid—is present in amounts from 0.1% in buttermilk derived from sweet cream to 0.9% in some cultured buttermilks. The percentage of lactose is reduced in proportion to the percentage of actual lactic acid. The quantity of fat may be as great as 0.5% in churned buttermilk and fat is often added to cultured buttermilk in comparable quantities, sometimes in the form of small flakes of butter, to cause it to simulate churned buttermilk. A typical composition of a cultured buttermilk when extra fat is not added,<sup>6</sup> is: 90.5% water, 0.1% fat, 3.6% protein, 5.1% carbohydrates (4.3% lactose, 0.8% lactic acid), and 0.7% ash.

A product equivalent to cultured buttermilk has recently been introduced which is prepared by the addition to unfermented milk of acid or acid anhydrides<sup>2</sup> to provide controlled acidity and desirable body characteristics. Flavoring materials may also be added. Acidity induced similarly has also been used in the production of other cultured products such as sour cream and cottage cheese.

#### CONDENSED BUTTERMILK

Commercial condensed buttermilk is made generally in creameries of large capacity from buttermilk derived from sour cream. It has a solids content of at least 27% and is used almost entirely as feed for animals. Sweetened condensed buttermilk prepared from sweet-cream buttermilk is in slight demand for use in ice cream and bakery products, but is not generally available. A typical composition of condensed sour-cream buttermilk is: 72.0% water, 1.5% fat, 9.9% protein, 12.0% lactose, 2.4% lactic acid and 2.2% ash.

#### DRY BUTTERMILK

Dry buttermilk made from sweet-cream buttermilk is used mostly in bakery products and dry food mixes. That made from sour-cream buttermilk is used in animal feeds. A typical composition of dry sour-cream buttermilk is: 4.8% moisture, 5.7% fat, 37.6% protein, 38.8% lactose, 5.7% lactic acid, and 7.4% ash. A typical composition of dry sweet-cream buttermilk is: 3.0% moisture, 5.0% fat, 36.0% protein, 46.7% lactose, 1.4% lactic acid, and 7.9% ash.

#### CHEESE

Cheese is a complex food product consisting mainly of casein, fat, and water. Lactose is practically never present in well-ripened



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hard cheese. The percentage of fat in cheese is influenced to the greatest degree by the percentage of fat in the milk used for its manufacture. The milk may have its original fat content, or may have been skimmed to varying degrees, or even enriched by addition of cream. The methods of manufacture also influence considerably the composition of cheese. Although a list of the varieties of cheese manufactured in the various countries of the world would contain several hundred different names,<sup>4</sup> the number of

TABLE 20  
COMPOSITION (IN PER CENT) OF SOME COMMON CHEESES<sup>1-6</sup>

	Mois- ture	Fat in Solids	Fat	Protein	Ash
Parmesan					
Typical	30.0	37.1	26.0	36.0	5.1
Federal Standard <sup>a</sup>	<32.0	>32.0			
Provolone					
Typical	38.0	45.1	28.0	28.0	4.0
Federal Standard	<45.0	>45.0			
Cheddar					
Typical	37.0	51.1	32.2	25.0	3.7
Federal Standard	<39.0	>50.0			
Pasteurized Process American					
Typical	40.0	50.0	30.0	23.2	4.9
Federal Standard	<39.0	>50.0			
Domestic Swiss					
Typical	39.0	45.9	28.0	27.5	3.8
Federal Standard	<41.0	>43.0			
Pasteurized Process Swiss					
Typical	40.0	44.8	26.9	26.4	5.1
Federal Standard	<41.0	>43.0			
Roquefort					
Typical	40.0	50.8	30.5	21.5	6.0
Federal Standard	<45.0	>50.0			
Blue					
Typical	40.0	50.8	30.5	21.5	6.0
Federal Standard	<46.0	>50.0			
Brick					
Typical	41.0	51.9	30.5	22.2	4.4
Federal Standard	<44.0	>50.0			
Limburger					
Typical	45.0	50.9	28.0	21.2	3.6
Federal Standard	<50.0	>50.0			
Camembert					
Typical	52.2	51.7	24.7	17.5	3.8
Federal Standard		>50.0			
Neufchatel					
Typical	55.0	51.1	23.0	18.0	2.0
Federal Standard	<65.0		20.0		
Cream					
Typical	51.0	76.9	37.7	8.0	1.2
Federal Standard	<55.0		33.0		
Cottage, creamed					
Typical	78.3	19.3	4.2	13.6	1.0
Federal Standard	<80.0		4.0		

<sup>a</sup> < signifies "not more than." > signifies "not less than."

distinct types is approximately 20. Only the more important types of cheese manufactured or sold in the United States are considered here. They are listed in Table 20 and described in approximately the order of their decreasing hardness when ready for consumption as follows: Parmesan, Provolone, Cheddar, Domestic Swiss, Roquefort and Blue, Brick, Limburger, Camembert, Neufchâtel, Cream, and Cottage. Table 20 gives typical percentages, derived from several sources,<sup>4,6</sup> of the chief components of these cheeses and the federal standards for their composition.<sup>6</sup>

### **Parmesan**

Grana is the name given in Italy to cheeses of the type known as Parmesan in the United States. Reggiano, Parmigiano, Lodigiano, and Emiliano are some of the names originally employed to indicate the place of manufacture. Parmesan is relatively large Italian-type cheese made from partially skimmed milk. After the making and salting, which take about 40 days, the cheese is stored in cool, well-ventilated rooms for 1 to 2 years or longer and is rubbed occasionally with oil. Parmesan becomes very hard and must be grated before using.

### **Provolone**

This is a type of Italian plastic-curd cheese commonly made in the United States. The curd is kneaded and stretched in a plastic condition, being kept hot by frequent immersion in hot water. This working expresses whey and air from the curd and produces a compact cheese. The cheese is cured in various characteristic shapes and sizes and often possesses a smoked flavor. Its composition is similar to that of Swiss.

### **Cheddar**

Cheddar is the most important cheese made in the United States from the standpoint of quantity. It is made from warmed and pressed curd obtained by the action of rennet and a lactic-acid culture on partially skimmed or whole milk. The milk is usually standardized to a definite ratio of fat to casein. It is marketed in several different sizes under various names and is eaten at many different stages of ripeness.

Washed curd cheese differs from Cheddar cheese principally in that the curd after milling is soaked in cold water for 5 to 30 min. before salting. It contains not more than 42% of moisture instead

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of 39%. The percentage of milkfat in the solids is not less than 50 in both cheeses.

Colby cheese has physical and chemical properties similar to Cheddar except that the curd has not been "cheddared" and the texture is more open and the body somewhat softer. It contains not more than 40% moisture.<sup>1</sup>

Substantial quantities of Cheddar and related varieties are converted into Pasteurized Process American cheese.

### Domestic Swiss

This is the counterpart in the United States of the Emmental of Switzerland. It is made from heated and pressed curd obtained by the action of rennet on partially skimmed or whole milk, and is ripened by special gas-producing bacteria which cause characteristic "eyes" or holes to develop. This milk is usually standardized to a definite ratio of fat to casein. Some Swiss cheese is converted into Pasteurized Process Swiss or blended with Cheddar or American cheese.

### Blue-Vein Cheeses

A blue-vein cheese is made from cow's milk in the United States and elsewhere and is known as Blue cheese. Other well-known rennet cheeses characterized when ripe by a blue-green mold throughout are the Gorgonzola of Italy and the Stilton of England, both made from cow's milk.

Roquefort is a rennet cheese made in the vicinity of Roquefort in southern France from sheep's milk. The curd is neither heated nor pressed. It is inoculated throughout with a mold known as *Penicillium roqueforti* and ripens with the growing of the mold. The fully ripened cheese is friable and shows on a cut surface a marbling which is caused by veins of blue-green mold.

### Brick

Brick cheese is a rennet-curd, whole-milk cheese ripened by bacteria and is intermediate in characteristics between Swiss and Limburger. It is made mostly in the United States. Similar cheeses are Port du Salut, Oka, and Munster. The latter is usually milder in flavor than Brick cheese.

### Limburger

This is a soft ripened cheese made from cow's milk. The ripening process takes about two months and produces a characteristic intense flavor and aroma.

### Camembert

Camembert is a soft, mold-ripened cheese which originated in France, but which is now made also in the United States. The mold remains on the rind of the cheese and secretes enzymes which penetrate the body of the cheese to carry out the ripening process. Probably because of the shorter ripening period, the domestic Camembert is usually more moist than the typical foreign cheese. Brie is another cheese of this type.

### Neufchâtel, Cream, and Cottage

To avoid spoilage and loss by action of molds and bacteria, these soft, unripened cheeses must be made from milk of good quality, under strict sanitary conditions, stored at low temperatures, and marketed within a comparatively short time after manufacture. Domestic Neufchâtel is made from partially skimmed or whole milk or a mixture with cream. Hence, the percentage of fat may vary considerably from the typical value given in Table 20 (p. 45). Lactic acid producing bacteria are employed for flavor production, and rennet is used for coagulating. Cream cheese differs from whole milk Neufchâtel in that cream is used and its fat content is correspondingly higher. Both Neufchâtel and Cream cheeses are worked to a smooth paste.

Cottage cheese is made from pasteurized skim milk. The curdling is accomplished by lactic acid bacteria and a very small amount of rennet or "coagulator." The curd is washed but not worked and the granules may be any size up to  $\frac{1}{2}$  in. diameter. It may be marketed as small curd (country style) or large curd (popcorn style). Cream is usually added to the curd so that it contains at least 4.0% milkfat and not more than 80.0% moisture. This product is called creamed Cottage cheese.

### Pasteurized Process Cheese

Pasteurized process cheese is a blend of fresh and aged natural cheeses which have been shredded and mixed. Disodium phosphate or sodium citrate is added as an emulsifying agent, and the blend is heated (pasteurized), packaged, and cooled, after which no further ripening occurs. The blend may consist of one or two or more varieties of natural cheese and may contain pimentos, fruits, vegetables, or meats. Smoked cheese or smoke flavor may also be added. The flavor of Pasteurized Process cheese depends largely upon the flavor of the natural cheese used. It may be modified by the addi-

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tion of flavoring materials. A typical composition is 50.5% milkfat-in-solids and 39.5% moisture.

### **Pasteurized Process Cheese Food**

Pasteurized Process cheese food is prepared in much the same manner as process cheese except that it contains less cheese, with nonfat dry milk, or whey solids and water added. This results in a lower milkfat content and more moisture than in process cheese. It may also contain pimentos, fruits, vegetables or meats, or may have a smoked flavor. The federal standard of identity requires a milkfat content of not less than 23.0% and a moisture content of not more than 44.0%.

### **Pasteurized Process Cheese Spread**

Pasteurized Process cheese spread is made in much the same manner as cheese food but generally contains more moisture and the milkfat content is usually lower. A stabilizer such as carob bean gum, or sodium alginate is used in the preparation of this product to prevent separation of ingredients. The federal standard of identity requires a milkfat content of not less than 20.0%, and a moisture content of more than 44.0% but not more than 60.0%.

### **Coldpack Cheese**

Coldpack cheese or Club cheese is a blend of the same or two or more varieties of fresh and aged natural cheese, as in process cheese, except that the cheese is mixed into a uniform product without heating. It may have a smoked flavor. The federal standards of identity are specific with respect to the milkfat and moisture content depending upon the variety or blend of cheese used.

## WHEY

This is the product remaining after removal of casein and fat from milk in the process of cheese making. Whey varies considerably in composition depending on the composition of the original milk, on the cheese-making process of which it is a by-product, and on the techniques of the cheese maker. Fresh whey contains most of the salts, lactose, and serum protein of the milk, and, in addition, other nitrogenous compounds including traces of casein, and a little milkfat. Storage of whey for any considerable time results in a decrease in the percentage of lactose, an increase in acidity, and breakdown of the nitrogen compounds. A small quantity of whey is used as a commercial source of lactose. Whey is used as a stock

feed either directly or as the condensed or dried product. Some is also dried for human food. A typical whey from the manufacture of Cheddar cheese consists of 93.2% water, 0.3% fat, 0.9% protein and nitrogenous matter, 5.1% lactose (including lactic acid), and 0.5% ash. Swiss cheese whey contains a larger percentage of fat and it is less acid than Cheddar whey. Running whey through a cream separator reduces the percentage of fat to slightly less than 0.1.

### Whey Butter

Where the volume of whey handled and the percentage of fat present are sufficient to pay the cost, whey is run through a separator. The cream produced is usually blended with sweet cream producing a butter identical in composition with whole milk cream butter. There may be differences in the physical and chemical characteristics depending upon the percentage of whey cream used.

### Whey Cheese

Wheys in which the noncasein protein has not been coagulated may be made into whey cheese by either of two methods. In one, whey is concentrated by boiling until it has, on cooling, a firm sugary consistency. In the other, the whey protein is coagulated by heat and acid, and the curd skimmed off and pressed in hoops. In some cases the whey protein is coagulated from whole milk or partly skimmed milk or from whey to which skimmilk has been added. The first process produces Mysost or Primost; the second, Ricotta or Zigar. The composition of Mysost varies so widely that it is not practical to give a typical analysis. Ricotta (fresh) usually contains approximately 70% moisture, 4% fat, 19% protein, 4% lactose, and 3% ash.

### Condensed Whey

Plain condensed whey is not a commonly available commercial product. It is an intermediate product in the manufacture of lactose, animal feeds, dried whey, and some food products, such as process cheese foods. An analysis not published elsewhere is: 48.1% water, 2.4% fat, 7.0% protein, 38.5% lactose, and 4.0% ash. Sweetened condensed whey has been prepared for use in food products, especially candies.<sup>7</sup> Such a product contains, typically: 24.0% water, 1.7% fat, 5.0% protein, 28.5% lactose, 38.0% sucrose, and 2.8% ash.

## COMPOSITION OF MILK PRODUCTS

### Dried Whey

Dried whey has been used chiefly in mixed feeds for animals. However, sweet whey processed and dried under sanitary conditions is being used in increasing amounts as a component of food. A typical composition is: 4.5% moisture, 1.1% fat, 12.9% protein, 71.2% lactose, 8.0% ash, and 2.3% lactic acid.

### FROZEN DESSERTS

Frozen desserts containing milk products include ice cream, frozen custard, ice milk, and sherbet. Most states require that plain ice cream contain not less than ten per cent milkfat. Some states have a minimal fat standard of 12%, one, 14, and two as low as 8%. In states in which the minimal fat in plain ice cream is 10% or greater, the minimum for fruit, nut or chocolate ice cream is usually 2% less. Over half the states have a minimal standard for milk solids of either 18 or 20%. The standards for frozen custard are usually those for either plain, fruit or nut ice cream, plus a minimal proportion of egg yolk. Sherbet is a frozen product containing about 4% milk solids, approximately 30% sugar, and a small percentage of citric acid. Ice milk varies widely with a range of 2 to 7% milkfat; otherwise, it has most of the characteristics of ice cream.

In 1960, a federal standard of identity was promulgated for frozen desserts. The standard encompasses definitions and standards of identity for ice cream, frozen custard, French ice cream, French custard ice cream, ice milk, fruit sherbets, and water ices. These standards form Part 20 in the Code of Federal Regulations (Title 21).

Below are compositional requirements:

Plain ice cream—	Milkfat, min. %	10
	Total milk solids, min. %	20
	Stabilizer, max. %	0.5
	Emulsifier, max. %	0.2
	Wt. per gallon, min. lb.	4.5
Fruit sherbet—	Food solids per gallon, min. lb.	1.6
	Milkfat, min. %	1.0
	max. %	2.0
	Total milk solids, min. %	2.0
	max. %	5.0
	Stabilizer, max. %	0.5
	Emulsifier, max. %	0.2
Frozen custard—	Wt. per gallon, min. lb.	6.0
	Acid (as lactic), min. %	0.35
	Milkfat, min. %	10
	Total milk solids, min. %	20
	Stabilizer, max. %	0.5

## FUNDAMENTALS OF DAIRY CHEMISTRY

	Emulsifier, max. %	0.2
	Wt. per gallon, min. lb.	4.5
	Food solids per gallon, min. lb.	1.6
	Egg yolks, (solids), min. %	1.4 <sup>a</sup>
Ice milk also fruit, nut or chocolate ice milk—	Milkfat, min. %	2.0
	max. %	7.0
	Total milk solids, min. %	11.0
	Stabilizer, max. %	0.5
	Emulsifier, max. %	0.2
	Wt. per gallon, min. lb.	4.5
	Food solids per gallon, min. lb.	1.3

<sup>a</sup> Except not less than 1.12% when flavors or bulky flavors are added.

### FERMENTED MILKS

In addition to the beverage buttermilks already discussed, there are fermented milks of several other types produced and consumed in the United States. Kefir and Kumiss are examples of fermented milk containing both lactic acid and alcohol. They may contain as much as 3.0% alcohol and as much as 2.5% lactic acid, but smaller percentages are more usual. Yoghurt is a fermented milk consisting of a firm curd that is conveniently eaten with a spoon. It contains 1.6 to 4.0% fat and 12.5 to 16.0% total milk solids, depending on whether the milk was skimmed or concentrated or milk-solids-not-fat added.

### COMMERCIAL LACTOSE

Lactose was made in the United States prior to 1940 almost exclusively from whey formed in the manufacture of casein precipitated by hydrochloric acid. Now, because of increased demand and decreased production of casein, lactose is made in the United States almost exclusively from cheese whey. The refined lactose of commerce contains over 99.7% lactose, not more than 0.05% ash, not more than 0.02% nitrogen, and not more than 0.02% fat.

### COMMERCIAL CASEIN

Casein is manufactured from skimmilk, precipitation being accomplished either by acidification or by the use of rennet. Bacterial production of lactic acid in the skimmilk, or addition of hydrochloric or sulfuric acid are the means of acidification. Differences in composition of casein are caused mostly by differences in the type of manufacturing process employed and in the care taken in the precipitation and washing of curd. It is not feasible to give an average or a typical analysis of casein, since values vary so much within



## COMPOSITION OF MILK PRODUCTS

their range and since methods of analysis are not uniform. The percentage of moisture in caseins of all types usually falls within the range 6.0 to 8.0; that for fat, within the range 0.7 to 2.0. The percentages of fat in two caseins should not be compared unless it is known that the methods of determination were the same. Rennet casein consistently contains between 7.0 and 8.3% ash. The fact that rennet casein is essentially a calcium caseinate accounts for this comparatively large value. Discussion of ash percentages of caseins is complicated by the fact that neglect to add an oxidizing agent to the sample before ashing causes values to be low; also, if a casein containing less than 2.5% ash is incinerated without addition of a metal salt of an organic acid, varying proportions of  $P_2O_5$  are volatilized. Pure casein contains 1.82%  $P_2O_5$  in organic combination, and for this reason values of ash percentages less than 2.5 are open to question, unless it is known that precautions were taken to prevent loss of  $P_2O_5$  during incineration. Values less than 1.82% should be disregarded unless it is known both that  $P_2O_5$  was not volatilized and that 1.82 was subtracted from the determined percentage to give what is called by some European investigators "true" ash. What may be called "total" ash of natural-sour casein is usually within the range of 2.5 to 4.5%; of hydrochloric and sulfuric caseins, 3.0 to 5.5%; and of grain-curd casein, 1.9 to 3.0%.

### Sodium Caseinate

Sodium caseinate, edible grade, is made from isoelectric casein which has been prepared under standards of cleanliness and control necessary for production of edible products. The casein is solubilized with food-grade caustic soda and the resulting soluble product is spray dried. Conditions are adjusted to give a moisture content of five per cent or lower on the finished product.

Sodium caseinate is being used in increasing quantities as a protein supplement in dietetic and bakery products, in stews, soups, and the like.

### REFERENCES

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